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THE AGRICULTURAL SPECIES OF BENT GRASSES.

Part I.—RHODE ISLAND BENT AND RELATED GRASSES.

By CHARLES V. PIPER, *Agrostologist in Charge of Forage-Crop Investigations.*

Part II.—THE SEEDS OF REDTOP AND OTHER BENT GRASSES.

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CONTENTS.

	Page.
GENERAL SUMMARY	1
Part I.—RHODE ISLAND BENT AND RELATED GRASSES:	
Introduction	3
Redtop	4
Fiorin	5
Rhode Island bent	7
Colonial bent	10
Velvet bent, or brown bent	11
Carpet bent	11
Summary	12
Literature cited	14
Part II.—THE SEEDS OF REDTOP AND OTHER BENT GRASSES:	
Introduction	15
Trade conditions	15
Distinguishing the seeds	17
General structure	17
Distinguishing characters	18
The seeds described	19
Seed of redtop	19
Seed of Rhode Island bent	20
Seed of velvet bent	21
Impurities of commercial seed	22
Summary	25

GENERAL SUMMARY.

Part I of this bulletin discusses the identity and characteristics of Rhode Island bent and the immediately related grasses, namely, redtop, fiorin, velvet bent, and "creeping bent." The distinguishing botanical and agricultural characteristics of these grasses are pointed out and two of them are illustrated with figures.

Three of these grasses have been handled commercially by seedsmen, namely, redtop, Rhode Island bent, and "creeping bent," in a mixture here referred to as South German mixed bent. The evidence indicates that little genuine Rhode Island bent seed has been on the market in recent years.

Rhode Island bent is a "very valuable grass for lawns and golf courses, not much inferior to creeping bent." Large quantities of seed

of this can be gathered from natural pastures in New England, and it is believed that the gathering and marketing of this seed will become an important resource, based entirely on the merits of the grass. In view of the fact that redtop seed can always be distinguished by an expert and the South German mixed bent can be distinguished by the incidental weed seeds present, there is good reason to believe that the industry of gathering Rhode Island bent seed and of establishing a large sale for it on its merits can be reestablished.

Part II of the bulletin discusses the seeds of the species of bent which occur in the trade. Conditions prevailing in the trade relating to the sale of redtop seed as seed of the finer bents and the importation of seeds of the finer bents under various and misleading names are set forth.

The characteristics by which seeds of certain of the kinds of bent can be distinguished are stated. Illustrations are given to make clear the statements made.

The principal impurities of domestic and of imported seed are illustrated in the belief that this information may be useful in distinguishing imported seed from that grown in this country.

The most important fact is that redtop seed can be distinguished from seed of Rhode Island bent and of South German mixed bent to the extent that the seed, either alone or mixed, can be detected with certainty.

The principal misbranding in the trade is the substitution of redtop seed for seed of one of the other bents, a procedure which will be discouraged by this bulletin.

With the information which this bulletin furnishes, it is believed that progressive seedsmen and others will promptly engage in the production of seed of the finer bent grasses.

Part I.—RHODE ISLAND BENT AND RELATED GRASSES.

By CHARLES V. PIPER, *Agrostologist in Charge of Forage-Crop Investigations.*

INTRODUCTION.

"Rhode Island bent" as the name of a grass appeared in American agricultural literature at least as early as 1790 (4, p. 123)[1] and its modification "Rhode Island grass" as early as 1841 (17, p. 115). Perhaps no other grass has given rise to more confusion regarding its identity, both in commercial use and in botanical publications. The reason for this lies largely in the fact that many species and subspecies of bent grasses, the botanical genus Agrostis, are very similar to one another and consequently are much confused, even in botanical works.

The treatments by different botanists of the species and varieties centering about common redtop (*Agrostis alba* L. of most botanists) are much involved. Some of the confusion is due to the different opinions held by botanists as to the systematic value of the numerous forms described, but the matter has become more entangled by errors in the application of the names, both common and technical. The subject of botanical names is of interest primarily to botanists, but it has caused some confusion in the seed trade also and consequently in the culture of the bent grasses. The most noteworthy recent attempt to clarify the nomenclature is that of Ascherson and Graebner (1, p. 172–183). In Europe, however, many more varieties occur than in America, so the subject is correspondingly more complex.

From the agronomic standpoint it is necessary to consider only the forms which are utilized in agriculture or the seeds of which have been handled commercially. These forms are six in number, as follows:

Redtop (*Agrostis palustris* Huds.; *Agrostis alba* L. of most botanists), the most valuable species of bent for agricultural use. This grass is too coarse to make really fine turf. The commercial seed is grown in the United States, mainly in Illinois.

Fiorin (*Agrostis maritima* Lamarck; *Agrostis stolonifera* var. *latifolia* Sinclair), formerly a much-exploited grass, propagated vegetatively, the seed never having been gathered commercially. It occurs along the North Atlantic coast in America as well as in Europe.

Rhode Island bent (*Agrostis tenuis* Sibth.; *Agrostis vulgaris* With.), a much finer grass than redtop and probably the most abundant grass in New England, where it makes up much of the pastures. Commercial seed has been gathered principally in Rhode Island, but in recent years only to a very limited extent.

[1] The serial numbers in parentheses refer to "Literature cited," p. 14.

Colonial bent. This is identical with Rhode Island bent, as is proved by cultures. Commercial seed has in recent years been gathered in small quantities in New Zealand.

Velvet bent, or brown bent (*Agrostis canina* L.), a distinct but variable European grass, sparingly introduced into the United States. Seed is always present in the bent seed gathered in Germany, here referred to as South German mixed bent, as velvet bent makes up a varying proportion of the turf grown from such seed. By an unfortunate error the name *Agrostis canina* has been associated with Rhode Island bent by recent writers, and this has caused much confusion.

Carpet bent. This grass is apparently always present in turf grown from South German mixed bent [1] seed. On turf 3 years old grown from such seed, carpet bent usually constitutes one-tenth to one-fourth of the turf. It produces long, creeping branches, so that each plant at length forms a dense circular mat of fine turf. The botanical name to be applied to carpet bent is still doubtful.

REDTOP.

Redtop (fig. 1) is now the common name employed for the most important of the bent grasses. In England, and formerly at least in New England, the names whitetop and white bent were used.

FIG. 1.—Redtop (*Agrostis palustris*). The detailed figures show the structure of the ligule, a spikelet in bloom, and separate parts of the spikelet.

Redtop is the largest and most valuable of the grasses here described. Commercial seed has been grown for at least 40 years mainly in southern Illinois. The grass is, with scarcely a doubt, not indigenous to North America, but has been introduced from Europe.

Botanically, redtop is usually known as *Agrostis alba* L. The original specimens of Linnæus still preserved in his herbarium are of this grass, but his description and references apply partly to wood meadow grass (*Poa nemoralis* L.).

The name *Agrostis stolonifera* L. is also frequently applied to redtop, owing to some doubt concerning the type specimens in the Linnæan herbarium. Some botanists consider that this name really belongs to the grass also known as *Agrostis verti-*

[1] South German mixed bent is often sold in the trade as "creeping bent," and usually under the scientific name *Agrostis stolonifera*. This name, the first binomial given to any grass of the group here discussed, belongs to a plant growing about Upsala, Sweden, there known as Kryp-hven, that is "creeping bent." It is quite intermediate in characteristics between redtop and fiorin, as determined from authentic Swedish specimens secured from Dr. Carl Lindman, of Stockholm, Sweden, but it is seemingly very different from carpet bent.

cillata Vill., a noncultivated species mostly without stolons, because a specimen of that is in the Linnæan herbarium and because some of the references relate in part to the latter species; but the more conservative judgment of other botanists is that the name properly belongs with the stoloniferous grass that is native about Upsala, Sweden, there known as Kryp-hven.

In commercial use, and formerly also in botanical publications, appears the name *Agrostis dispar* Michaux, described from South Carolina. Hitchcock has examined Michaux's original specimen and pronounces it the same as ordinary redtop.

Agrostis capillaris is still another botanical name attached by some seedsmen to redtop. This name as used originally by Linnæus in 1762 is based on various older descriptions, including one of his own published in the Flora Lapponica in 1737. The evidence regarding the identity of this plant is much involved, and modern Swedish botanists no longer consider it to be a Scandinavian plant. In any event the evidence is clear that the name can not be applied to redtop.

The name marsh bent is also used occasionally in the seed trade, applied to redtop. This name apparently arose as an anglicizing of *Agrostis palustris* Huds., which, according to a letter from Dr. Otto Stapf, is based on a plant not distinguishable from *Agrostis alba* of Linnæus's herbarium. However, various English botanists use the name marsh bent in connection with a stoloniferous form.

Another common name applied to redtop, especially in the Southern States, and formerly at least in Pennsylvania, is herd's-grass. This name appears in agricultural literature as applied to redtop as early as 1804 (18, p. 192–202). Inasmuch as the name herd's-grass or herd-grass was applied in New England to timothy, botanical and agricultural writers have commonly pointed out that the herd's-grass of Pennsylvania and the Southern States is redtop. In Pennsylvania usage the name herd's-grass was applied both to *Agrostis alba* and to *A. vulgaris*, not only by agricultural writers, such as Mease (10), but also by the Pennsylvania botanist Muhlenberg (11, p. 69). Darlington (3, p. 10), however, restricts the name to *Agrostis vulgaris*. Herd's-grass is still a common name for redtop in the Southern States.

On the whole it would seem best to drop the name *Agrostis alba*, because it was founded partly on *Poa nemoralis*, and to use as the botanical name of redtop the next older name, *Agrostis palustris* Huds.

FIORIN.

Fiorin is the common name of an Irish grass which was much exploited as an agricultural crop by Dr. William Richardson, of Moy, Ireland, in the early part of the nineteenth century. This grass was

recommended mainly for moor lands. It is characterized by its habit of forming long, creeping, leafy stolons, or runners, which often reach a length of 3 to 10 feet and grow until late in the season. From the accounts of the culture of this grass given by Richardson (14)[1] and others, it was propagated only in a vegetative manner, usually by scattering the stolons over the ground and covering slightly with soil. Apparently seed was rarely gathered or utilized, and there is no evidence that it ever entered into the seed trade.

From contemporary accounts, as well as from authentic preserved specimens, there is no doubt that this is one of the grasses that have been referred to *Agrostis stolonifera* L. There is doubt, however, as to whether it is exactly identical with Linnæus's original plant, which grows about Upsala, Sweden, and is there known as Kryp-hven.

The stoloniferous bents of Europe are a puzzling group, and some botanists describe as many as six different forms. Sinclair (15, p. 227–228, 343), who calls Richardson's fiorin *Agrostis stolonifera* var. *latifolia*, states that the varying results obtained by different experimenters were due in part to their growing different botanical varieties. Mackay (9, p. 298) states that he saw fine crops of fiorin on a reclaimed bog in Connemara, Ireland, the grass having been introduced three years previously with sand from the seashore. The grass was promptly tested in America, but never achieved any importance. A stoloniferous bent that occurs in America spontaneously is common along the seacoast from Delaware to Newfoundland, and by American botanists is usually designated *Agrostis alba* var. *maritima*, but it is not certain that it is native. A very similar grass occurs on the coasts of Oregon, Washington, and British Columbia, possibly introduced.

Whatever the exact botanical identity of fiorin may be, it is clearly distinct from both redtop and Rhode Island bent in its stoloniferous habit. The names creeping bent and stoloniferous bent, as used by English botanists, both refer to a grass with creeping stolons and properly do not apply to any form without stolons. The name fiorin has been used by modern seedsmen, however, in connection both with redtop and with South German mixed bent.

Fiorin is nowhere now cultivated in America, and apparently its culture in Europe did not long outlast Richardson's propaganda. It is not clear why this is the case, as numerous recorded experiments indicate that the grass is valuable for culture on moor lands. It is possible that the sale of redtop seed as fiorin may be partially responsible for the agricultural decadence of fiorin.

The stolon-producing bents are apparently constant in this habit. Stebler and Volkart (16, p. 115) state that the habit proved constant

[1] Richardson's writings were voluminous and appear in many of the agricultural journals of his time.

in their cultures, extending over many years. Sinclair (15, pp. 227, 230) records the same conclusion. This has also been the case in our limited experiments.

RHODE ISLAND BENT.

Rhode Island bent (fig. 2) is the most common and abundant grass on well-drained soils in New England and New York. It has every appearance of being a native, but it is highly probable that it was introduced from Europe, as it is not distinguishable from *Agrostis vulgaris* With., described originally from England.

There can be no doubt that this is the grass to which the name Rhode Island bent properly applies. Both the literary and traditional evidence clearly lead to this conclusion, which, however, has been obscured by the fact that many recent writers erroneously associated the name Rhode Island bent with *Agrostis canina* L., a grass rare in America.

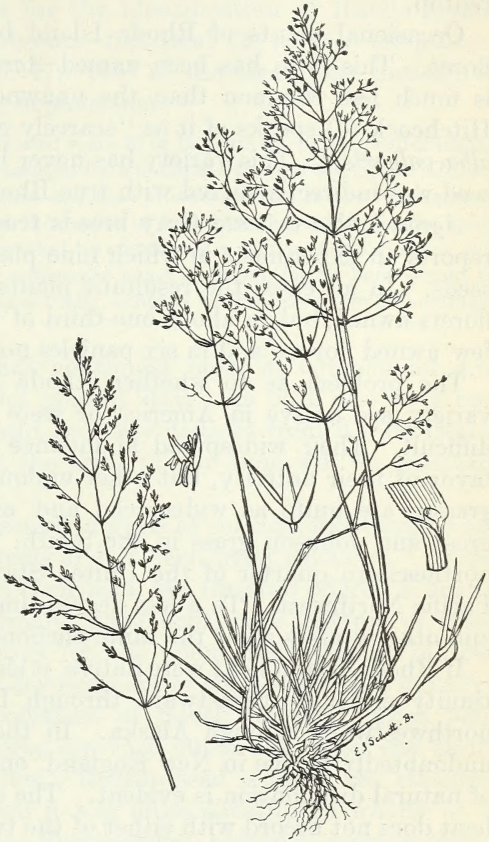

FIG. 2.—Rhode Island bent (*Agrostis tenuis*). The detailed figures show the ligule and a single spikelet.

It will suffice to point out that Flint (5, p. 18–20), in 1857, was perfectly familiar with both Rhode Island bent (*Agrostis vulgaris*) and white bent (*Agrostis alba*), the distinctive characters of which he contrasts.

Howard (7), before this, distinguished "*Agrostis vulgaris major*, large redtop, western redtop," from "*Agrostis vulgaris minor*, small redtop, finetop, etc.," but erroneously associated the name "Rhode Island, or Burden grass" with the former. Potter (13) in 1889 described the methods of saving seed of Rhode Island bent used by him on Prudence Island. On this island the common grass to-day is *Agrostis vulgaris*, while *Agrostis canina*, if it occurs there at all, is at least very rare.

The name redtop in New England commonly applies to *Agrostis vulgaris* and not to *Agrostis alba*, which formerly at least was known generally as white bent or whitetop.

Among the common names that have been applied in New England to Rhode Island bent are the following: Rhode Island grass, fine agrostis, fine bent, furzetop, Burden (or Burden's) grass, and small redtop.

Occasional plants of Rhode Island bent possess an awn to the floret. This form has been named *Agrostis alba aristata* Gray. It is much less common than the unawned Rhode Island bent, and Hitchcock (6) speaks of it as "scarcely more than a form of *Agrostis alba vulgaris*." This variety has never been cultivated except as its seed was indirectly mixed with true Rhode Island bent.

Agrostis alba aristata Gray breeds true or nearly so. Jenkins (8) reports an experiment in which nine plants were grown from awned seeds. In all cases the resultant plants had at least some of their florets awned, but in about one-third of the panicles there were but few awned florets, and in six panicles no awns could be detected.

The problem as to whether Rhode Island bent and its awned variety are native in America or were introduced from Europe is difficult. Their widespread abundance in New England argues in favor of their nativity, but other undoubtedly introduced perennial grasses are quite as widespread and abundant, such as Bermuda grass and Johnson grass in the South, bluegrass over much of the northeastern quarter of the United States, and velvet grass in the Pacific Northwest. To a less degree timothy, orchard grass, redtop, and other grasses show the same phenomenon.

If Rhode Island bent were native, it should show geographical continuity either northeastward through Labrador and Greenland or northwestward through Alaska. In the case of Old World plants undoubtedly native in New England, one or the other of these lines of natural distribution is evident. The distribution of Rhode Island bent does not accord with either of the two possible routes of natural spread, which argues in favor of the grass being introduced by man.

Prof. M. L. Fernald, of Harvard University, whose long and intimate knowledge of the northeastern American flora makes his testimony of special value, writes—

> I am now ready to state that *Agrostis vulgaris* is in all probability an introduced, though very extensively naturalized, grass. I can find no evidence of it in the more remote and essentially untrodden areas in the interior of Newfoundland or Gaspe, although in the neighborhood of settlements the plant has taken freely to primitive habitat. Variety *aristata* I should call unquestionably indigenous, though I have occasionally found it growing by roadsides or in the turf of lawns. Its chief habitats, however, are the absolutely untouched woodlands and thickets.

Rhode Island bent, by a curious and unfortunate misidentification, has for a long time been referred to both in seedsmen's catalogues and in botanical publications as *Agrostis canina* L. *Agrostis canina*, popularly known in England as brown bent, is sparingly introduced in America. It has never been handled pure in the seed trade, although its seed is a common impurity in seed of South German mixed bent.

The authority responsible for the identification of Rhode Island bent as *Agrostis canina* is obscure, but Beal (2, p. 151) adopted it in 1887, while Olcott (12, p. 179–180) in the same year mentioned the name with the following explanation:

> The botanic situation was complicated some 10 or 12 years ago by the well-meaning efforts of a Providence merchant—assisted by a botanist—to stem the tide of adulteration. This injured his own business and that of seed growers in the Narragansett country, who relied for a living on their sales of fine Agrostis seed under the trade name of Rhode Island bent. After what he considered a sufficient examination this worthy botanist declared that the systematic name of Rhode Island bent should be *Agrostis canina*, and this name was actually adopted in the lists of several eminent seedsmen.

This unfortunate error has continued both in commercial and botanical publications to the present day. As both the seed and other characters of brown bent are very distinct from Rhode Island bent, it is to be hoped that the error in due time will be generally recognized.

Rhode Island bent was formerly a grass of considerable commercial importance, but in recent years it has been little gathered. Seedsmen continue to include it in their lists, but the seed offered is nearly always redtop or South German mixed bent, or a mixture of these two. There were two reasons for the commercial decline of true Rhode Island bent: (1) The development of the redtop-seed industry in Illinois and (2) the importation of South German mixed bent seed. The seeds of these three are very much alike and can easily be substituted one for another. Redtop seed is much the cheapest of the three. For this reason it was often substituted wholly or in part for Rhode Island bent. Furthermore, redtop is more valuable for hay and pastures than Rhode Island bent, so that the use of the latter for these purposes declined. For fine lawns, however, Rhode Island bent is much superior to redtop.

Rhode Island bent makes a fine, close turf, scarcely inferior to that produced by South German mixed bent. At the time of writing (January, 1918) no seed of South German mixed bent is available, owing to conditions arising out of the European war. Rhode Island bent is, however, a very satisfactory substitute for use on lawns and golf courses, for which there exists a very large demand. Prac-

tically unlimited quantities of the seed could be gathered in New England and New York, and it is hoped that the conditions existing will bring about its commercial reestablishment. Even in competition with South German mixed bent there would continue to be a large demand for Rhode Island bent, so that the industry of gathering the seed should be permanent.

Rhode Island bent only rarely produces creeping stolons or runners, and these when present seldom exceed 6 inches in length. Single plants of Rhode Island bent rarely form patches of turf more than 6 inches in diameter.

Inasmuch as it seems advisable to drop the name *Agrostis capillaris* L., the name to be used should be the oldest one that undoubtedly belongs to Rhode Island bent. This is *Agrostis tenuis* Sibthorp, 1794, while *Agrostis vulgaris* With. dates from 1796. It is desirable that seedsmen use the name *Agrostis tenuis* in connection with Rhode Island bent, as *Agrostis vulgaris* has too commonly but erroneously been associated with redtop.

Rhode Island bent makes a very fine turf, dark green in color, and is apparently a pure strain in this respect. The seed may contain a small percentage of redtop, as this coarser grass is not rare in some New England pastures, but the percentage of redtop is seldom enough to be noticeable in the resultant turf.

From the practical standpoint of growing fine turf there is little reason to prefer any other bent to Rhode Island bent. The latter grass is so abundant in New England and New York that practically limitless quantities of seed could be gathered. With care, fields containing an appreciable quantity of redtop may be avoided, as when in bloom redtop is easily distinguished by its taller habit, broader leaves, coarser panicle, and longer ligule.

In view of these facts, it seems highly desirable that American seedsmen handle Rhode Island bent seed on its merits. There seems to be no reason why the New England seed can not be gathered at least as cheaply and probably more so than the South German mixed bent. It is not unlikely that special seed-gathering machines may be adapted or devised to further this industry. At present a vast quantity of this seed goes to waste, as even on well-grazed pastures the seed crop is little diminished.

COLONIAL BENT.

During the last few years seed from New Zealand has been put on the market under the names colonial bent and browntop. Turf and plants grown from this seed show it to be identical with Rhode Island bent.

VELVET BENT, OR BROWN BENT.

Velvet bent, or brown bent (*Agrostis canina* L.), is native to Europe but sparingly introduced into the United States. A small percentage of the seed commonly occurs in South German mixed bent. On putting greens seeded to the latter, the velvet bent can easily be detected by its forming very dense circular patches of a rather pale or apple-green color. The leaves are finer than those of carpet bent, usually 9 nerved, and under a lens are seen to be minutely roughened. The ligule is long. The patches of turf made by single plants of velvet bent are often a foot or more in diameter and make what is probably the finest of all grass turfs. Under the conditions at Washington, D. C., velvet bent rarely forms seeds, the flowers being replaced by propagula resembling bunches of small leaves, which propagate the plant vegetatively. When grown alone, velvet bent forms much-branched stolons 4 or 5 inches long and often with dense masses of leaves at the tip. This character does not appear in closely clipped turf.

A source of a supply of seed of this grass is a great desideratum, as the turf it makes is of such exquisite quality and beauty of appearance.

CARPET BENT.

Carpet bent is one of the most desirable turf plants that always occurs in turf grown from South German mixed bent seed. Seedsmen commonly label South German mixed bent seed *Agrostis stolonifera* and use such common names as creeping bent, South German fiorin, and stoloniferous bent grass.

The only source of supply of commercial seed has been southern Germany. It is said to have been gathered from natural areas of grass and not specially planted for seed production.

Most of the plants grown from South German mixed bent seed are apparently identical with Rhode Island bent. The leaves have short ligules, and when grown to maturity the plants are indistinguishable from Rhode Island bent.

In old plantings of South German mixed bent, especially on putting greens, at least four forms of turf may usually be distinguished: (1) Bright green very fine-leafed circular patches, (2) dark green larger circular patches, (3) blue-green similar patches, and between these (4) medium green turf not in definite patches. The bright green very fine-leafed plant is velvet bent (*Agrostis canina*). The grass that does not form definite patches is probably nearly all Rhode Island bent. The other two sorts that form circular mats are forms of what is here called carpet bent.

When portions of these last two are planted alone they produce creeping runners 3 or 5 feet long the first season, making circular

mats 5 to 7 feet in diameter, and with relatively few flowering culms. It is by this stoloniferous character that carpet bent is most strikingly distinguished from Rhode Island bent, but the ligules are long and the flowering panicles rather dense.

Experiments are now under way to test turf grown from different forms of carpet bent by vegetative multiplication. It is found very easy to plant by cutting the long runners into pieces 2 to 3 inches long. This method is entirely practicable where a uniform fine quality of turf is desired. One plant 6 feet in diameter will give enough cuttings to sow an area 30 feet square. Such pure strains avoid the particolor effect so characteristic of greens seeded to South German mixed bent.

The botanical name to be applied to carpet bent is not yet certain.

SUMMARY.

(1) Rhode Island bent is a very common grass in New England and New York and less common west to Michigan and south to Virginia. The evidence points clearly to its being an introduction from Europe.

(2) Rhode Island bent seed was formerly gathered in considerable quantities, mainly in Rhode Island, but in recent years very little of the genuine seed has reached the market.

(3) The commercial decline of Rhode Island bent seed seems to be correlated with the development of the redtop-seed industry in Illinois. Redtop seed is cheaper and therefore was substituted for Rhode Island bent by dealers.

(4) Rhode Island bent is an excellent grass for fine turf, and for this purpose is excelled only by velvet bent and carpet bent.

(5) Rhode Island bent seed could be gathered nearly pure in almost unlimited quantities from old pastures in New England and New York. By the use of labor-saving machinery the seed should be harvested cheaply enough to command a large market.

(6) Colonial bent, or browntop, the seed of which is gathered in New Zealand in small quantities, is the same as Rhode Island bent.

(7) The botanical names of Rhode Island bent and the related grasses, redtop, fiorin, creeping bent, and velvet bent, have been much confused. Some of the common names also have been erroneously interchanged. The name fiorin really belongs to a grass formerly cultivated that possesses long, creeping, leafy runners and was propagated solely by these runners, the seed never having been handled commercially. This name therefore should not be used either for redtop or for Rhode Island bent. The name *Agrostis canina* belongs to velvet bent and should not be applied to Rhode Island bent, which botanically is *Agrostis tenuis*.

(8) Carpet bent (*Agrostis* sp. indet.) and velvet bent (*Agrostis canina* L.) make up much of the turf on 3-year-old lawns grown from South German mixed bent seed. This mixed seed constitutes at present the only commercial supply of these two fine bents.

(9) Redtop and fiorin produce rather coarse turf as contrasted with the three fine bents. Of the latter, velvet bent makes the densest, finest turf and carpet bent the next best, while Rhode Island bent is slightly coarser. All these, however, either alone or in mixture, make the finest, smoothest turf of all northern lawn grasses.

(10) It is recommended that seedsmen employ the following common and scientific names for the grasses described in this bulletin.

Redtop—*Agrostis palustris* Huds.
Rhode Island bent—*Agrostis tenuis* Sibth.
Colonial bent—*Agrostis tenuis* Sibth.
Velvet bent—*Agrostis canina* L.
South German mixed bent—*Agrostis spp.*

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Part II.—THE SEEDS OF REDTOP AND OTHER BENT GRASSES.

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INTRODUCTION.

It is important that the seed of redtop be distinguished from that of other bent grasses which have finer leaves and stems, because it is often sold as seed of the latter. Redtop seed has been imported from Europe as seed of the finer bent grasses, and more rarely the latter has been imported as seed of redtop.

The seed of common redtop (*Agrostis palustris* Huds.; *Agrostis alba* L. of most botanists) is mostly produced in southern Illinois. The seed of Rhode Island bent (*Agrostis tenuis* Sibth.), a very abundant grass in New England and New York, formerly was gathered in commercial quantities, but little, if any, of it has been in the market in recent years. Colonial bent seed has been received from New Zealand. Plants grown from this seed have proved to be *Agrostis tenuis* and therefore botanically identical with Rhode Island bent. The seed of South German mixed bent, believed to be produced in southern Germany only, has been imported from different points in Europe and from England. "South German mixed bent" is not a trade name, but it is used in this bulletin to avoid confusion with the trade names in use. This seed is a mixture of the seed of redtop, velvet bent (*Agrostis canina* L.), and one or more undetermined species or varieties of bent.

TRADE CONDITIONS.

The relation to each other of the kinds of seed under discussion as they appear in the trade is essentially as follows: American-grown redtop seed is not likely to have mixed with it seed of the other bent grasses. Rhode Island bent seed, now at least rare in the market, is likely to contain some seed of redtop, since the latter grass is common where the Rhode Island bent prevails. Seed of velvet bent (*Agrostis canina*) does not occur in the trade as pure seed, and but rarely as a predominating ingredient of South German mixed bent seed. It appears to enter the American trade only through the imported seed produced in southern Germany.

The samples of colonial bent which the writer has seen contained considerable chaff, but the bent seed was the purest *Agrostis tenuis* that has come under his observation. Seed of South German mixed bent, imported under one name or another, exhibits the impurities characteristic of seed produced in Europe, and in this way can be

distinguished from seed grown in this country when considered in bulk quantity. This seed has been imported under the names *Agrostis stolonifera, Agrostis canina,* creeping bent, South German agrostis, South German fiorin, or some similar name, and as Rhode Island bent.

One hundred samples of seed imported under some one of the above names or a similar name and taken at random from among custom-house samples representing importations prior to 1915 were labeled as follows: "*Agrostis stolonifera,*" 54 samples; "*Agrostis canina,*" 27 samples; "creeping bent," 9 samples; "South German fiorin," 3 samples; "German fiorin," 2 samples; "German agrostis," 2 samples; "Rhode Island bent," 2 samples; and "True German agrostis," 1 sample. Of these samples, 5 consisted of redtop only, while 25 contained redtop as the principal ingredient. In the remaining 70 samples, seed of the finer bent grasses predominated. Seed of velvet bent was present in each of the 95 samples, and in some this appeared to amount to as much as 40 per cent or more of the mixture. The remaining undetermined fine bent seed in these lots predominated in most of the 70 samples.

From a wider range of samples of imported seed, 27 were found to consist of redtop only. But 4 of these samples were imported as redtop, the others being labeled as follows: "*Agrostis stolonifera,*" 9 samples; "creeping bent," 5 samples; "grass seed," 5 samples; "fancy agrostis," 2 samples; "*Agrostis canina,*" 1 sample; and "*Agrostis vulgaris,*" 1 sample. Careful examination of these samples of redtop seed failed to show any evidence that the seed was produced in Europe, and good reasons appeared for believing that it was grown in this country. Instances were also noted of the entry of seed of the finer bents, labeled "redtop."

The importations of Agrostis during 1916 represented 48 lots, totaling 46,663 pounds. Two lots amounting to 1,508 pounds consisted of redtop only. One lot only, of 3,900 pounds, was South German mixed bent seed. The remaining 45 lots, totaling 41,255 pounds, came from a single firm in Arnheim, Holland. The seed in each of these lots was chiefly redtop, together with South German mixed bents varying in quantity from a mere trace to an appreciable proportion. Of the 48 lots imported in 1916, 27 were entered as "creeping bent," 17 as "Rhode Island bent," 2 as "*Agrostis canina,*" 1 as "*Agrostis stolonifera,*" and 1 as "redtop." One of the two lots of redtop was imported as "redtop"; the other as "creeping bent." The single lot of South German mixed bent seed was imported as "Rhode Island bent."

Owing to the European war no importations of South German mixed bent seed were made in 1917 or prior to March 6, in 1918, the date of this writing.

DISTINGUISHING THE SEEDS.

In consequence of the close relationship existing between redtop and the other bent grasses, their seeds are very similar in appearance and are readily mistaken, one kind for another, unless they are examined critically with the aid of a low-power compound microscope or a high-power hand lens.

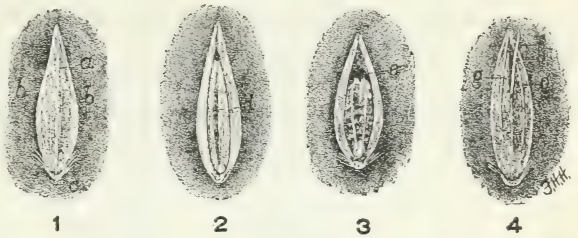

FIG. 3.—Hulled seeds of redtop (*Agrostis palustris*), enlarged, illustrating the general structure of seeds of bent grasses: 1, Back of the lemma; *a*, the keel vein; *bb*, the marginal veins; *c*, the callus. 2 and 3, The opposite side of the seed; *d*, the palet, not wrinkled and covering the grain; *e*, the palet, wrinkled and shorter than the grain. 4, Back of a lemma having an awn (*f*) and intermediate veins (*gg*).

The distinguishing characters of the minute seeds of redtop and other bent grasses which are of practical value in recognizing the species are found in the seeds when freed from the outer enveloping chaff (fig. 3). This chaff (fig. 4) readily separates from well-matured seeds. In immature seeds the chaffy scales tend to cling to each other and to the inclosed seed. An unnecessary proportion of chaff usually constitutes a considerable part of the bulk of Rhode Island bent, colonial bent, and South German mixed bent seed. Domestic redtop is sold with the chaff present as "chaffy" redtop and free of the chaff as "fancy," "hulled," or "recleaned" redtop.

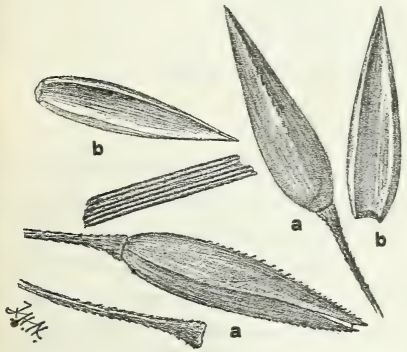

FIG. 4.—Chaff, or hull, of redtop seed: *a*, Whole spikelets usually devoid of seed in "chaffy" grades; *b*, separated scales of the same; *a* and *b* represent the outer chaff of the seed. (Enlarged.)

An opinion on the kind of seed found in a given sample and its probable source is based upon (1) the structural characters of the seed, which show its kind, and (2) the impurities found in the sample, such as other grass seeds, weed seeds, and chaff, which usually indicate the source of production.

GENERAL STRUCTURE.

Freed from the two outer chaffy scales, called the glumes, an individual seed of redtop or of the other bent grasses consists of a grain lying between two unequal, more or less inclosing scales (fig. 3, *1* and *2*). The larger scale, which exceeds the length of the grain, is termed the lemma. The smaller is termed the palet or palea. The palet is especially important in distinguishing the kind of seed. While the palet varies somewhat in the same kind of seed, it differs

greatly in seed of certain different kinds. The base of the seed has a collarlike thickening, the callus, which sometimes bears a few bristlelike white hairs. The apex of the seed is pointed and three angled or four angled, depending upon the number of veins at the apex of the lemma.

The lemma has at least three evident longitudinal veins, one near each margin, the marginal veins, and one in its center, the keel vein (fig. 3, *1*). These veins produce the 3-angled form of the apex of the lemma. Often the keel vein does not develop to the apex of the lemma, and it sometimes develops into a bristle, or awn, projecting from the keel of the lemma (fig. 3, *4*). In either event two additional veins, the intermediate veins, appear between the keel and marginal veins. The intermediate and marginal veins then give the apex of the lemma a 4-angled form. The lemma is thin and usually translucent at the apex, becoming thicker and opaque toward the base. The translucent portion of the lemma gives the seed of some species a silvery white appearance.

The palet has two longitudinal veins if sufficiently well developed (fig. 3, *2* and *3*). It is very thin, often translucent and showing the darker grain beneath, sometimes transparent and obscure. It varies in size and texture and in its tendency to be free from or adherent to the grain.

The grain usually is reddish brown, oblong in outline, and finely wrinkled at maturity. The interior, or endosperm, may be dry and somewhat resistant to pressure on crushing, or it may be semifluid and soft when crushed, depending on the species of the seed.

DISTINGUISHING CHARACTERS.

The distinguishing characters of the hulled seeds of redtop and the other commercial bent grasses appear in the comparative size and form of the seed, the texture and surface markings of the lemma, the character of the awn, the length of the palet compared with the length of the lemma and of the grain, its texture and degree of adhesion to or its freedom from the grain, the size and consistency of the grain, the associated weed seeds and other seeds, and the character of the chaff, if present.

In practical seed analysis, small bulk samples of commercial seed of redtop, Rhode Island bent, colonial bent, and South German mixed bent can be distinguished one from another. The velvet-bent seed in the South German mixed bent seed can be distinguished and its true proportion determined. In mixtures of the commercial kinds determination within 5 per cent of the true proportions of redtop seed and seed of the fine bent grasses taken collectively can be made. The seed of the fine bent grasses found in South German mixed bent seed, exclusive of the velvet-bent seed it appears always

to contain, can not at present be identified with certainty or distinguished by the seed alone from American-grown Rhode Island bent seed and colonial bent seed. Finally, the seed of carpet bent or strictly stoloniferous forms of bent can not be recognized at present. These phases of the subject are open to further investigation.

The commercial kind of seed is often suggested and sometimes determined by evidence of its source of production which appears in the associated weed seeds and other seeds found in the sample. Though certain kinds of weed seeds are found in both domestic and imported seed, others are strongly suggestive either of domestic or of foreign production. In this matter, the absence of certain kinds of seeds is as helpful as the presence of others.

THE SEEDS DESCRIBED.

The following descriptions of the seeds of redtop, Rhode Island bent, and velvet bent are based chiefly upon their appearance under a low-power compound microscope. When the distinguishing characters are recognized by this means the use of a high-power hand lens enables one to recognize with a considerable degree of accuracy the kinds in bulk quantity or in mixtures. A complete qualitative and quantitative analysis requires the use of a compound microscope and of laboratory methods.

SEED OF REDTOP (AGROSTIS PALUSTRIS HUDS.; AGROSTIS ALBA L. OF MOST BOTANISTS).

Lemma 0.05 to 0.08 of an inch in length, lanceolate to lanceolate-oblong in outline, somewhat glistening, the longest lemmas exceeding the grain about one-third their length, the upper third or half of the lemma translucent and silvery white, the lower part opaque and often straw colored, the apex usually distinctly three angled, occasionally four angled by the absence of the keel vein; the surface glabrous, very finely and longitudinally striate; the awn occasional, rudimentary, straight, not spirally twisted, rarely exceeding the apex of the lemma or bent and twisted, arising near the apex of the lemma, rarely as low as the middle of the latter, often a mere projection from the surface (fig. 3, *4*); hairs at the callus present or wanting; palet exhibiting two types in appearance: (1) Not wrinkled, scarcely translucent, evidently striate, usually equaling or exceeding the grain (fig. 3, *2*); (2) wrinkled, often shorter than the grain and between two-thirds

FIG. 5.—Seeds of redtop (*Agrostis palustris*), enlarged and natural size: In seeds *a*, *b*, and *c* the palet is not wrinkled and covers the grain. In seeds *d* and *e* the palet is wrinkled and shorter than the darker grain. (The natural size is shown at *f*.)

and three-fourths the length of the lemma, rarely but half the length of the grain, obscurely striate, translucent, showing the grain, more or less adherent to the grain, rarely wholly adherent and transparent and therefore obscured till separated from the grain (fig. 3, *3*); veins of the palet often distinct, sometimes scarcely evident; grain oblong in outline, often robust, mostly reddish brown and finely wrinkled, dry and mealy when crushed under slight pressure (fig. 5).

FIG. 6.—Seeds of Rhode Island bent (*Agrostis tenuis*), enlarged and natural size. In seeds *a* and *b* the palet is not wrinkled. In seeds *c* and *d* the palet is wrinkled and translucent. In seed *e* the transparent, closely adherent palet is obscured against the darker grain. (The natural size is shown at *f*.)

SEED OF RHODE ISLAND BENT (AGROSTIS TENUIS SIBTH.; AGROSTIS VULGARIS WITH.).

Lemma 0.04 to 0.07 of an inch in length, ovate-lanceolate to narrowly lanceolate in outline, narrowly pointed at the apex, exceeding the grain by one-fourth or less of its length, not glistening, the upper half or more of the lemma translucent and silvery white, opaque toward the base; the surface of the lemma glabrous and finely striate longitudinally; the apex of the lemma usually distinctly three angled; an aborted awn occasional from near the apex or rarely not lower than the middle of the lemma, straight, not spirally twisted, rarely equaling the apex of the lemma, such awn-bearing lemmas sometimes four angled at the apex; seeds of some plants all or nearly all bearing similar awns, each awn arising between one-fourth and one-third the length of the lemma from its base, the awn bent near the apex of the lemma and spirally twisted below the bend; the lemmas thus awned four veined at the apex (fig. 7); palet sometimes not wrinkled, semitranslucent and striate, rarely equaling the grain, usually clearly shorter than the grain, between one-half and two-thirds the length of the lemma, or often scarcely exceeding half the length of the grain, usually wrinkled and partially adherent to the grain, often wholly adherent and transparent and therefore obscured till separated from the grain; veins of the palet commonly wanting; grain slenderly oblong in outline, dry and mealy when crushed. (Figs. 6 and 7.)

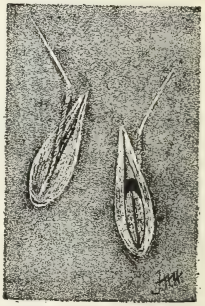

FIG. 7.—Seeds of the awned form of Rhode Island bent (*Agrostis tenuis*). (Enlarged.)

Compared with seeds of redtop, the seeds of Rhode Island bent are, in general, more slender, smaller, less glistening, and lighter colored;

the lemma and palet are thinner, somewhat more translucent, the palet more frequently adherent to the grain and transparent. The palet is distinctly smaller than is usual in redtop and shorter in proportion to the length of the lemma. The nonwrinkled, striate, often opaque palet, which commonly equals or exceeds the grain in redtop, is conspicuously rare in seeds of Rhode Island bent. Seeds bearing a twisted, bent awn from near the base, common in Rhode Island bent seed, are absent in redtop. The grain in Rhode Island bent-grass seed is somewhat smaller and more slender than in redtop.

Seeds of colonial bent (*Agrostis tenuis*) present all the characteristics observed in the seeds of Rhode Island bent.

SEED OF VELVET BENT (AGROSTIS CANINA L.).

Lemma 0.04 to 0.07 of an inch in length, ovate-lanceolate or elliptical in outline, exceeding the grain from slightly to one-fourth its length; surface usually minutely granular, obscuring the faint longitudinal striation; surface dull and pale straw colored or apparently darker, due to the grain appearing through the lemma, which often is translucent except at the opaque base; hairs at the callus present or wanting; many seeds awned, the awn varying from a mere projection from the surface to a long bristle exceeding the lemma, bent near the apex of the latter and spirally twisted below the bend, many of the intermediate forms straight and not twisted, the awns mostly arising near the middle of the lemma, the longest ones occasionally arising as low as one-fourth of the length of the lemma from its base; apex of the lemma four veined, owing to the absence of the keel vein above the middle of the lemma; palet a minute, obscure scale of subequal length and width, appearing as a whitish spot at the base of the grain; grain usually smaller than in redtop or Rhode Island bent, its surface more or less exposed between the margins of the lemma, soft, and under slight pressure exuding the semifluid endosperm. (Fig. 8.)

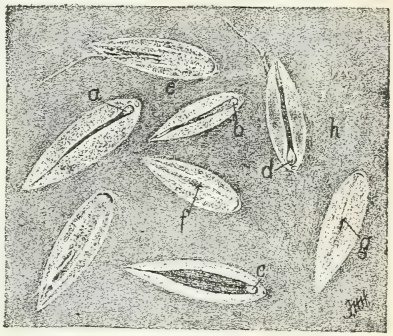

FIG. 8.—Seeds of velvet bent (*Agrostis canina*), enlarged and natural size. Seeds *a*, *b*, *c*, and *d* exhibit the minute palet. Well-developed awns appear at *d* and *e*. Rudimentary awns are indicated at *f* and *g*. A much-exposed grain is shown at *c*. (The natural size is shown at *h*.)

A greater proportion of the seeds of velvet bent are small than is the case in redtop or Rhode Island bent. The ovate-lanceolate or elliptical outline, the dull granular surface, the large proportion of awned seeds, the absence of an evident palet, and finally the soft semifluid grain serve readily to distinguish these seeds from those

of redtop, Rhode Island bent, and colonial bent. By the same means, the seeds of velvet bent can be recognized when occurring in South German mixed bent seed.

IMPURITIES OF COMMERCIAL SEED.

An examination of many commercial samples of the seeds of redtop and of South German mixed bent shows that their origin, whether domestic or foreign, can usually be determined. The studies of the writer in this connection include domestic redtop seed, redtop imported from Europe, South German mixed bent seed imported from Germany, Holland, and England, and a limited number of samples of Rhode Island bent seed from Rhode Island and of colonial bent seed from New Zealand. The samples of domestic redtop seed and of South German mixed bent seed examined were sufficient in number to show the prevailing kinds of incidental seeds occurring with these commercial seeds. A smaller number of samples of redtop seed

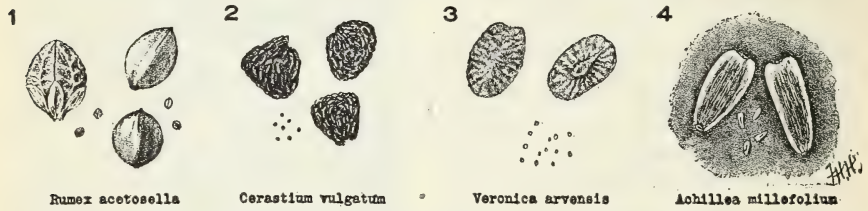

FIG. 9.—Seeds occurring frequently in both American-grown redtop seed and South German mixed bent seed (enlarged and natural size): 1, Sorrel (*Rumex acetosella*); 2, mouse-ear chickweed (*Cerastium vulgatum*); 3, corn speedwell (*Veronica arvensis*); 4, yarrow (*Achillea millefolium*).

known to have been imported from Europe, 27 in all, represented all that were available. The result of the examination of the samples of Rhode Island bent seed is supported by observations by the writer of the various plants occurring in fields in Rhode Island, where the Rhode Island bent grass grows abundantly.

Among the incidental seeds found in domestic redtop seed and in South German mixed bent seed certain kinds are common to both. This is to be expected, since these incidental seeds occur commonly with other kinds of commercial seed of both domestic and foreign origin, owing to the cosmopolitan character of their plants. Four of the kinds found most frequently are shown in figure 9. Exclusive of these kinds, others are confined almost wholly to the domestic redtop seed (fig. 10), and still others are confined to the South German mixed bent seed (fig. 11).

The plants represented by some of the kinds of seed considered characteristic of European-grown seed are known to occur in this country, but their distribution and the conditions of their growth are not such as to lead to the presence of their seed in domestic seed to the extent that they appear in the imported seed. Furthermore, the

absence from domestic seed of seeds characterictic of imported seed and the absence from imported seed of seeds characteristic of domestic seed afford additional evidence of the origin of the seed in question. It was by the presence of certain kinds of seeds and by the absence of others that the 27 samples of imported redtop seed were determined to be of American origin.

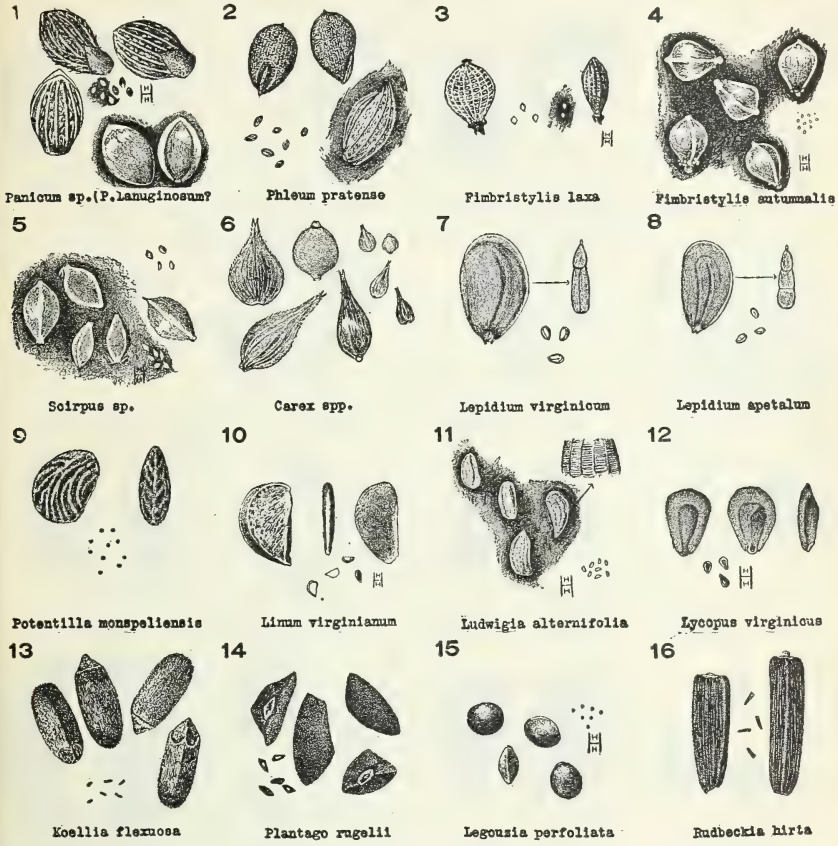

FIG. 10.—Seeds characteristic of American-grown redtop seed and Rhode Island bent seed (enlarged and natural size): 1, Panic grass (*Panicum* sp.); 2, timothy (*Phleum pratense*); 3, *Fimbristylis laxa*; 4, *Fimbristylis autumnalis*; 5, club rush (*Scirpus* sp.); 6, sedges (*Carex* spp.); 7, peppergrass (*Lepidium virginicum*); 8, peppergrass (*Lepidium apetalum*); 9, cinquefoil (*Potentilla monspeliensis*); 10, wild yellow flax (*Linum virginianum*); 11, rattlebox (*Ludwigia alternifolia*); 12, bugleweed (*Lycopus virginicus*); 13, mountain mint (*Koellia flexuosa*); 14, black-seeded plantain (*Plantago rugelii*); 15, Venus's-looking-glass (*Legouzia perfoliata*); 16, black-eyed Susan (*Rudbeckia hirta*).

Some of the lots of seed imported as South German mixed bent consisted largely of redtop, and in some instances this redtop seed is strongly suspected of being American seed that had been added to the bent seed. This is consistent with the fact that 18 of the 27 samples of imported American-grown redtop seed were brought to this country as South German mixed-bent seed under some trade name in common use, only 4 of the total number being entered as redtop seed.

The samples of Rhode Island bent seed examined may be considered fairly representative of New England grown seed which has not been recleaned. Several kinds of incidental seeds which are characteristically American were found in these samples. Furthermore, the weed seeds characteristic of South German mixed bent seed were absent from these samples. They contained no seed of

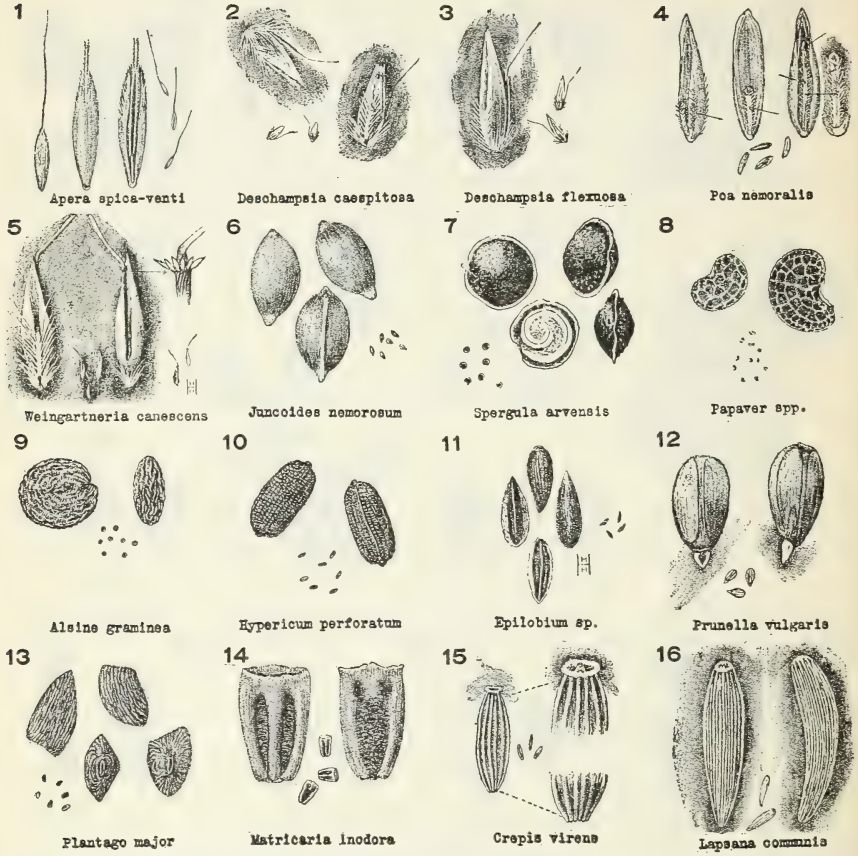

FIG. 11.—Seeds characteristic of South German mixed bent seed (enlarged and natural size): 1, Silky bent grass (*Apera spica-venti*); 2, tufted hair-grass (*Deschampsia caespitosa*); 3, wavy hair-grass (*Deschampsia flexuosa*); 4, wood meadow grass (*Poa nemoralis*); 5, *Weingartneria canescens*; 6, wood meadow rush (*Juncoides nemorosum*); 7, spurry (*Spergula arvensis*); 8, poppy (*Papaver* spp.); 9, starwort (*Alsine graminea*); 10, St. John's-wort (*Hypericum perforatum*); 11, willow herb (*Epilobium* sp.); 12, heal-all (*Prunella vulgaris*); 13, plantain (*Plantago major*); 14, scentless camomile (*Matricaria inodora*); 15, fireweed (*Crepis virens*); 16, nipplewort (*Lapsana communis*).

velvet bent (*Agrostis canina*), which has been found in every lot of South German seed examined.

The samples of colonial bent seed were too few to afford specific conclusions as to the range of the characteristic incidental seeds occurring with this seed; but certain kinds found are different from those occurring with seed of redtop or fine bents from other sources.

SUMMARY.

(1) Seed of the bent grasses occurring or likely to occur in the trade consists of (1) redtop mostly produced in Illinois; (2) Rhode Island bent mostly gathered in Rhode Island, but in recent years scarce in the American market; (3) colonial bent from New Zealand; and (4) South German mixed bent, imported under various names from Europe.

(2) The seed of redtop is the cheapest of the kinds of bent seed and often is substituted wholly or in part for the others.

(3) The seed of redtop in the domestic trade is chiefly, if not wholly, of domestic production and is free from seed of Rhode Island bent, colonial bent, and South German mixed bent.

(4) The seed of Rhode Island bent is American grown and likely to contain some seed of redtop; but it appears never to contain seed of velvet bent.

(5) The seed of colonial bent imported from New Zealand recently has appeared in this country. This seed is botanically identical with that of Rhode Island bent. The samples examined contained little or no redtop seed and were free from velvet bent.

(6) South German mixed bent seed is produced in southern Germany and has been imported for the American trade. Owing to the European war, but one importation of this seed was received in 1916 and none in 1917. It consists of a mixture of redtop seed, velvet-bent seed, and seed of undetermined fine bent, which usually predominates.

(7) The seed of redtop can be distinguished by the seed alone from that of Rhode Island bent, colonial bent, and the fine bent of South German mixed bent seed.

(8) Rhode Island bent seed can be distinguished from South German mixed bent seed and colonial bent seed chiefly by means of the incidental seeds of weeds and cultivated plants present.

(9) Individual seeds of Rhode Island bent apparently are indistinguishable from individual seeds of the undetermined fine bent found in South German mixed bent seed.

(10) South German mixed bent seed can be identified by the incidental seeds present and by the seed of velvet bent (*Agrostis canina*) it contains.

(11) Seed of velvet bent can be recognized, and its quantity in a sample of South German mixed bent seed can be determined accurately.

(12) Seed of carpet bent or that of any strictly stoloniferous form of bent can not be recognized at present, so far as is known.

(13) Redtop seed has been imported as South German mixed bent seed, presumably to be sold as the latter. Much of this seed, at least, was evidently American grown.

(14) Seed of South German mixed bent has been imported under several different names, which are not only confusing but in part are specifically incorrect and misleading.

(15) In some instances excellent South German mixed bent seed has been imported under the names of redtop and Rhode Island bent.

(16) The general condition of the domestic trade relating to the seed of the finer bent grasses is unreliable.

(17) The principal misbranding in the trade, and the most important to the buyer, is the sale of redtop seed for seed of the finer bents.

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